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DELAY ANALYSIS OF PRESSURE VESSELS FABRICATION USING FUZZY FMEA

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ABSTRACT

Every day, development continues to be carried out for various interests that will lead to the goal of improving people's welfare. The project is not only carried out in the field, but there are supporting jobs carried out in other locations such as equipment or certain parts which are usually carried out in workshops or sub-contracted to another company, one of which is pressure vessels. The number of project delays in the world and the manufacturing sector in Indonesia is quite high. In this study, will discuss the delay caused by fabrication, pressure vessel project, which benchmarked the Fabricator in Banten. Brainstorming is used to gather information about potential delays and the Focus Discussion Group (FGD) is used to determine the agreement of the factors that cause delays, Severity value, Occurency and Detection value. Risk Priority Nunber (RPN) obtains the result of the multiplications Severity x Occurency x Detection. 15 factors delay in getting as a cause of delay. More high the value of the RPN, higher the ranking of the causes of delay. In this study Fuzzy FMEA supports FMEA results in several rankings

KEYWORDS: Delay, Brainstorming, Forum, Discussion Group (FGD). FMEA & Fuzzy FMEA

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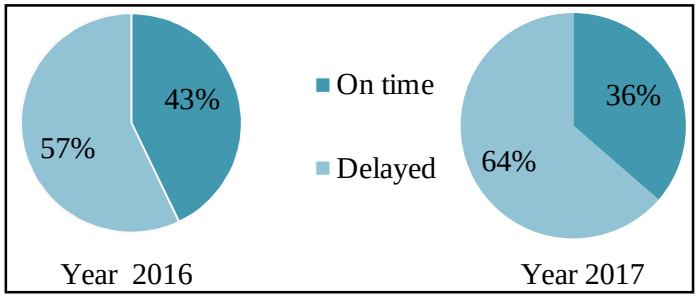
INTRODUCTION

Everyday, many activities are carried out to build regions or countries called projects. A temporary product is carried out to create unique products, services, or results (Anymous, 2004). Projects are complex, non-routine, one-time solutions based on time, budget, resources, and performance specifications designed to meet customer needs (Larson & Gray, 2011). The process of implementing projects is complex, usually requiring simultaneous attention to various human, budget, and technical variables (Pinto & Slevin, 1987). Not all project work is carried out in the field, there are some supporting parts that are made in the workshop, which is also one of the ways to accelerate the completion of the project. One of the equipment that is often fabricated is a pressure vessel.

Pressure vessels are closed containers designed to hold liquids or gases at temperatures different from the temperature of the environment. Pressure vessels are used for various applications in various industrial sectors such as the chemical industry (petrochemical plants), energy (power plants), oil and gas (oil & gas), nuclear power plants, food, and even household appliances such as boiler water heater or a pressure cooker. (Megyesy, 1998)

Delays in project completion occur throughout the world, but with different portions. In Indonesia, the number of delays in completing construction projects reached a high of 55% (Nadziroh, 2015). Where Indonesia is 55% experiencing delays in project completion time, India 57% (Salunkhe & Patil, 2014), Saudi Arabia 59% (Assaf & Al-Hejji, 2006) and Pakistan more than 90% (Nawas, Shareef, & Ali, 2013)

Based on data from a workshop of the EPC (Engineering, Procurement and Construction) company in Banten Province, Indonesia that serves pressure vessel manufacturing projects, the delay rate is still quite high. In 2016 there was a delay in project completion time of 57% of the total projects completed, whereas in 2017 there was a delay in project completion time of 64% of the total projects completed as shown figure 1.



Source: Data processed, 2016 and 2017

Figure 1: Percentage of Completion of Production at an EPC Company in Banten Province, Indonesia

Because of the importance of completing the project, this research will find the causes of the delay in the manufacturing of pressure vessels.

STUDY LITERATURE

Project Delay

Delays can be a source of disputes and demands between project owners or ordering materials with contractors as providers of manufacturing services. Completion of orders or projects on time is very important. The contractor will be subject to a fine or penalty in accordance with the contract if there is a delay, besides the contractor will also experience additional costs as long as the project is still ongoing. From the owner's side, the project delay will have an impact on reducing revenues due to the delay in the operation of its facilities.

Team collaboration is one of the main keys to successful project management. The assessment of the project schedule is needed to determine the basic change steps so that delays in project completion can be avoided or reduced.

In previous studies the factors of delay are grouped and described by (Assaf & Al-Hejji, 2006) (11) factors, namely: (1) Labour Factors, (2) Factors of Materials (3) Equipment Factors (4) Site characteristic factor (5) Financial factor (6) Environment factor (7) Change factor (8) Scope Factors and Contract / Job Document (9) Factors of Planning and Scheduling (10) Factors of Inspection Systems, Job Control and Evaluation (11) Managerial factors

FMEA

(McDermott, Mikulak, & Beauregard, 2009) FMEA is a systematic method for identifying and preventing product problems and process problems before they occur. FMEA prevents defects, increases safety and increases customer satisfaction. Ideally FMEA will be carried out at the stage of product or process development, even though FMEA can also produce large benefits when applied to existing products and processes. While the stages are (1) Reviewing / studying the process or product. (2) Brainstorm potential failure modes. (3) List of potential effects from each failure mode. (4) Set the level of severity for each effect. (5) Sets the event ranking for each failure mode. (6) Sets the detection ranking for each failure mode and / or effect. (7) Calculate RPN (Risk Priority Number) for each effect. (RPN) (8) Prioritize the failure

mode to act. (9) Take measures to eliminate or reduce high-risk failure modes. (10) Calculate the resulting RPN because the failure mode is reduced or omitted.

(R. S. Sinha & A. K. Mukhopadhyay, 2013) FMEA method is used to increase operational of cone crusher. Based on the failure data for one year used in the analysis and finally found the criticality rating of the equipment components, the damage and the reduction in equipment downtime as a reference to take appropriate and timely precautions. (Alok Kumar Singh, Sandeep Mondal, Alok Kumar Singh, 2017) at the Iron and Steel company examined the main causes of delays in the Raw Material Handling System (RMHS) System process. Failure Effect Mode and Critical Analysis (FMECA) are combined with Fault Tree Analysis (FTA), to find critical components of failure, which helps management to minimize the damage.

Brainstorming

Brainstorming is done after everyone on the team has an understanding of the process (or product), team members can begin to think of potential failure modes that can affect the manufacturing process or product quality. The way to do brainsorming is by giving an opinion session that will issue all ideas (McDermott et al., 2009). Team members must come to brainstorming meetings by conveying their ideas

Severity

The severity is indicated by numbers ranging from 1 to 10 where 10 represents the most severe and 1 represents the least for the failure mode given. Severity is assessed regardless of the possibility of occurrence or detection (McDermott et al., 2009)

Occurrence

Occurrence is the term used to indicate the model. Regarding that happened. This means the severity and detection of opportunities do not need to compile the assessment of events. The scale used for the event occurs is 1 to 10, where 1 is a rare event and number 10 indicates a frequent occurrence (McDermott et al., 2009)

Detection

Detection means the possibility that the failure model can be detected. Scale scores 1 to 10. A value of 1 indicates that an event will be easily detected while a value of 10 indicates that an event is difficult to detect (McDermott et al., 2009)

RPN (Risk Priority Number)

The RPN is given a numerical value for each potential failure model. This value is the result of multiplying values for severity, probability of failure, and the possibility of failure detection, with the following formula, namely RPN = Severity (S) x Occurance (O) x Detectability (D). The higher the RPN value, the more risky the potential failure model

Focus Discussion Group (FGD)

FGD is a rapid assessment, a semi-structured data collection method in which a group of selected participants deliberately gathers to discuss problems and problems based on a list of main themes compiled by researchers / facilitators (Kumar, 1987). (Manoranjitham & Jacob, 2007) made the FGD sequence as follows (1) Determine the objectives and

information needs of the focus group discussions. (2) The main topics are points or themes of discussion. (3) Prepare questions - questions or material discussed. (4) Final agreement and remove irrelevant questions.

Fuzzy FMEA

Fuzzy set theory defines the concept of possible distribution as a fuzzy limitation that acts as an elastic constraint on variable values. As a result of the importance of developing a better understanding of the interactions between probability and probability-especially in relation to the role these concepts play in natural language to improve our ability to develop machines that can simulate extraordinary human abilities to achieve goals that are not determined definitely in a fuzzy environment (Zadeh, 1978). The Fuzzy FMEA methodology helps in providing effective information for risk management and decision making under the uncertainty of the fuzzy FMEA approach which is considered to be proven to be more realistic than the traditional non-fuzzy approach.

METODOLOGY

The research method in this study is as follows:

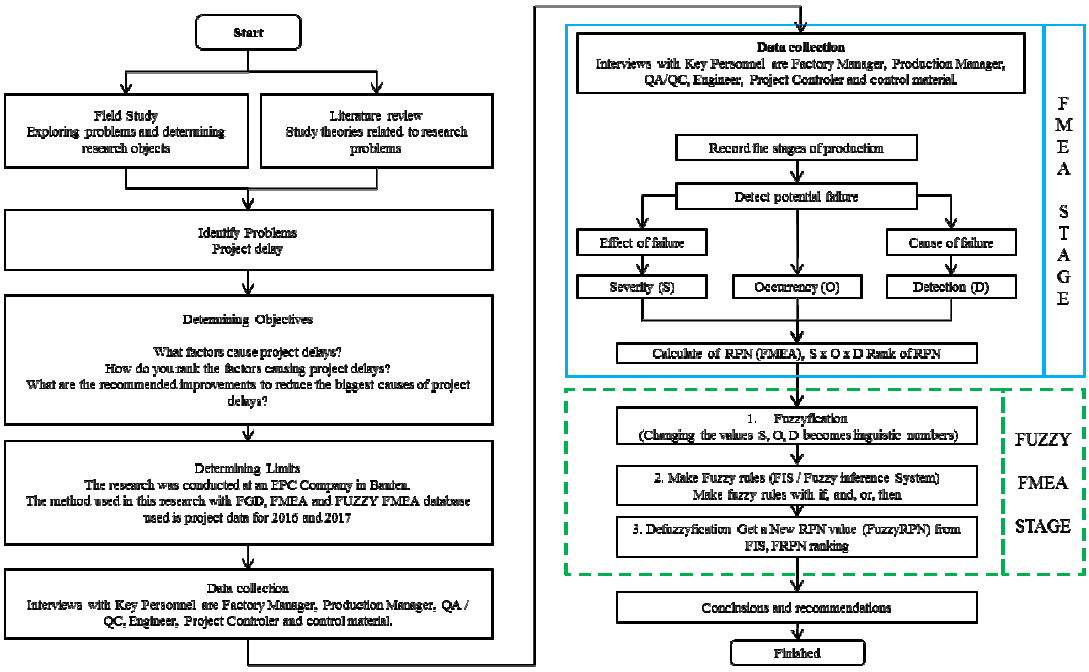


Figure 2: Research Method

Fuzzy Rule

Setting the input variable is to make the Severity (S), Occurency (O) and Detection (D) rules shown in table bellow.

Table 1: Linguistic Variable of Severity, Occurrence, Detection

Linguistic Variable	Symbol	Rank	Fuzzy Number
Very Low	VL	1,2	[0 0 2]
Low	L	3,4	[1 3 5]
Medium	M	5,6,7	[3 5 7]
High	H	8,9	[5 7 9]
Very High	VH	10	[8 10 10]

Source : (Khasha, Spehri, & Khatibi, 2013)

Fuzzy Inference System

Fuzzy Inference System in this reseach shown in table bellow.

Table 2: Fuzzy Inference System

SEVERITY:VL						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	VL	VL	VL	L
	L	VL	VL	VL	L	L
	M	VL	VL	L	L	M
	H	VL	L	L	M	M
	VH	L	L	M	M	H

SEVERITY:L						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	VL	VL	L	L
	L	VL	VL	L	L	M
	M	VL	L	L	M	M
	H	L	L	M	M	H
	VH	L	M	M	H	H

SEVERITY:M						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	VL	L	L	M
	L	VL	L	L	M	M
	M	L	L	M	M	H
	H	L	M	M	H	H
	VH	M	M	H	H	VH

SEVERITY:H						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	L	L	M	M
	L	L	L	M	M	H
	M	L	M	M	H	H
	H	M	M	H	H	VH
	VH	M	H	H	VH	VH

SEVERITY:VH						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	L	L	M	M	H
	L	L	M	M	H	H
	M	M	M	H	H	VH
	H	M	H	H	VH	VH
	VH	H	H	VH	VH	VH

Source : (Rachieru, Belu, & Anghel, 2013)

RESULTS

Based on the results of brainstorming and Focus Group Discusion (FGD) calculations, the results of the causes of delay and calculation of FUZY FMEA are as follows.

Table 3: FMEA & FUZZY FMEA

Failure No	Component And Function	Potential Failure Mode	Potential Effect(S) of Failure	Severity	Potential Cause of Failure	Occurency	Current Control Prevention	Current Control Detection	Detection	RPN	FRPN	Ranking RPN	Ranking FRPN
ENGINEERING													
F-1	Design	Incorrect Design	Re-Design	8	Inadequate experience from the designer	8	Approval / Review	Software	1	64	5	9	7
F-2	Design	Design is late approved	When design passes the schedule	7	The owner late agreed	1	Project Schedule	Reporting	6	42	5	12	8
PROCUREMENT													
F-3	Purchase of materials	Purchase is not smooth	Material arrived late	7	Purchase of imported materials	10	Purchase Status	Reporting	6	420	7	1	1
F-4	Purchase of materials	Purchase is not smooth	Material arrived late	7	Little alternative supplier	1	Vendor List	Reporting	6	42	4	13	12
PRODUCTION PROCESS													
F-5	Marking and cutting	Pieces do not match the drawing	Re-cutting	5	Error operator reading drawing	1	ITP (Inspection Test Plan)	Visual + Inspection Tools	6	30	3	14	14
F-6	Marking and cutting	Pieces do not match the drawing	Repair	5	Error machine	8	ITP (Inspection Test Plan)	Visual + Inspection Tools	6	240	6	3	3
F-7	Machine (forming, machining, drilling)	Part not standard	Repair	5	Error machine	8	ITP (Inspection Test Plan)	Visual + Inspection Tools	6	240	6	4	4
F-8	Machine (forming, machining, drilling)	Part not standard	Repair	5	Error operator reading drawing	8	ITP (Inspection Test Plan)	Visual + Inspection Tools	6	240	6	5	5

Table 4: FMEA & FUZZY FMEA Continued

Failure No	Component and Function	Potential Failure Mode	Potential Effect(S) of Failure	Severity	Potential Cause of Failure	Occurency	Current Control Prevention	Current Control Detection	Detection	RPN	FRPN	Ranking RPN	Ranking FRPN
F-9	Fit-up	Part tidak standar	The shape does not match the drawing	3	Error operator reading drawing	8	ITP (Inspection Test Plan)	Visual + Inspection Tools	6	144	5	7	9
F-10	Welding	Poor Quality	Rapair	5	Natural constraints (Wind, Temperature) + Manpower Discipline	9	Visual + Radhiography Test (NDE)	Visual + Inspection Tools	6	270	7	2	2
F-11	Final Inspection	Return to the previous work station	Re-check	1	Quality Control personnel are not careful in checking the previous process	8	ITP (Inspection Test Plan)	Report	7	56	5	10	10
F-12	Hydro testing	Pressure on the pressure gauge drops	Leakage	3	Bolt is not fast	9	Hydrotest Procedure	Visual + Inspection Tools	4	108	5	8	11
F-13	Finishing (Painting / Pickling)	Paint is not properly	Wet	6	Mistake paint material	8	Painting Procedure	Visual Inspection	1	48	4	11	13
F-14	Finishing (Painting / Pickling)	Striped color	striped	3	Natural obstacles (Wind, Temperature, Rain)	9	Alat Sling Hygrometer	Visual + Inspection Tools	6	162	6	6	6
F-15	Packing	Not neat	Repair	3	Operators do not understand the packing procedure	1	packing procedure	Visual Inspection	7	21	3	15	15

CONCLUSIONS

The Fuzzy-RPN value in tables above answer the research objectives. The results of the analysis show that there are two major priority failure modes based on the RPN and FRPN values, respectively, the first is F-3 Late material purchase because imported materials with RPN 420 values and FRPN 7 and the second is F-10 which is bad welding or repair because natural constraints (wind, temperature) & discipline of welders with values of RPN 270 and FRPN 7.

Based on the analysis of 5W + 1H to find out the root of the problem, the following results are obtained: First, the delay in purchasing materials due to imported materials is caused by the absence of SOPs and Work Instructions that specifically discuss important ingredients, which are only material purchases in general. So it was proposed that improvements be made to SOP and WI.

Second, welding is Poor Quality caused by the problem is the lack of a welder to maintain the cleanliness of the surface of the layer which will be welded both the material layer at the initial stage and the weld surface layer at the next layer and the absence of welding protection procedures from wind. So it is proposed to carry out periodic training and the implementation of reward and punishment. The second proposal is based on the observation that protection is not found to protect the environmental conditions (wind), the protection of the welding from the wind can be proposed by covering the plywood or welding habitat applied (ESAB, 2018).

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